Assignment 14.4 **Questions 5, 93, 95, 98, 102, 104, 112, 129**

5) Salts can be acidic, basic or neutral because strong acids product weak conjugate bases and weak acids produce strong conjugate bases. This is true for bases, but visa versa.

ex: **NH_4Cl** is an acidic salt

- NH_4^+ is the strong conjugate acid of the weak base, NH_3.
- Cl^- is the weak conjugate base of the strong acid, HCl.

KF - is a basic salt

- K^+ is the weak conjugate acid of the strong base, KOH.
- F^- is the strong conjugate base of the weak acid, HF.

93) $H_2SO_4 \longrightarrow H^+ + HSO_4^-$ K_{a1} reaction

$HSO_4^- \rightleftharpoons H^+ + SO_4^{2-}$ K_{a2} reaction

95) a. $K_{a1} = \dfrac{[H^+]\,[H_2PO_4^-]}{[H_3PO_4]} = 7.5 \times 10^{-3}$

$\dfrac{x^2}{0.10 - x} = 7.5 \times 10^{-3}$

$0 = 7.5 \times 10^{-4} - 7.5 \times 10^{-3}\, x - x^2$

$x = 0.024M$ **pH = 1.62**

b. $K_{a1} = \dfrac{[H^+]\,[HCO_3^-]}{[H_2CO_3]} = 4.3 \times 10^{-7}$

$\dfrac{x^2}{0.10} = 4.3 \times 10^{-7}$

$x = 2.1 \times 10^{-4}$ M

pH = 3.68

98) K_{a1} is very high, so $[H^+] = 0.0050M$ (from H_2SO_4)

$K_{a2} = 1.2 \times 10^{-2} = \dfrac{[H^+]\,[SO_4^{2-}]}{[HSO_4^-]}$

$0.012 = \dfrac{(0.0050 + x)\,x}{(0.0050 - x)}$

$0.000060 - 0.012x = 0.0050x + x^2$

$0 = -0.000060 + 0.017x + x^2$

$x = 0.0030$ M (from HSO_4^-)

$[H^+] = 0.0050 + 0.0030 = 0.0080$ M

pH = 2.10

Note: we had to account for H^+ produced by H_2SO_4 and HSO_4^-

102) Since methylamine is a stronger base than ammonia (higher K_b value), ammonia's conjugate acid (NH_4^+) is a stronger acid than methlyamine's conjugate acid ($CH_3NH_3^+$)

104) $C_2H_5NH_3Cl \longrightarrow C_2H_5NH_3^+(aq) + Cl^-(aq)$

acidic salt — conjugate acid of a weak base — conjugate base of a strong acid

$C_2H_5NH_3^+ \rightleftharpoons C_2H_5NH_2 + H^+$

0.25M *x* *x*

$1.79 \times 10^{-11} = \dfrac{x^2}{0.25}$

$x = 2.1 \times 10^{-6}$ M

$K_a \bullet K_b = K_w$

$K_a\,(5.6 \times 10^{-4}) = 10^{-14}$

$K_a = 1.79 \times 10^{-11}$

$[C_2H_5NH_3^+] = 0.25M$ **$[C_2H_5NH_2] = 2.1 \times 10^{-6}$ M**

$[Cl^-] = 0.25M$ **$[H^+] = 2.1 \times 10^{-6}$ M** **$[OH^-] = 4.8 \times 10^{-9}$ M**

K_a and K_b for conjugates can be found by using $K_a \times K_b = K_w$

112) a. $KCl \longrightarrow K^+ + Cl^-$

KCl is ***neutral*** (conjugates of strong acid and strong base)

b. $NH_4C_2H_3O_2 \longrightarrow NH_4^+ + C_2H_3O_2^-$ ***(Neutral; $K_a = K_b$)***

$NH_4^+ \rightleftharpoons NH_3 + H^+ \qquad K_a = 5.6 \times 10^{-10}$

$C_2H_3O_2^- + H_2O \rightleftharpoons HC_2H_3O_2 + OH^- \qquad K_b = 5.6 \times 10^{-10}$

c. $CH_3NH_3Cl \longrightarrow CH_3NH_3^+ + Cl^-$ K_b for $Cl^- \approx 0$; ***acidic salt.***

$CH_3NH_3^+ \rightleftharpoons CH_3NH_2 + H^+ \qquad K_a = 2.28 \times 10^{-11}$

d. $KF \longrightarrow K^+ + F^-$ K_a for $K^+ \approx 0$, ***basic salt***

$F^- + H_2O \rightleftharpoons HF + OH^- \qquad K_b = 1.4 \times 10^{-11}$

e. $NH_4F \longrightarrow NH_4^+ + F^-$ ($K_a > K_b$ so it is an ***acidic salt***)

$NH_4^+ \rightleftharpoons NH_3 + H^+ \qquad K_a = 5.6 \times 10^{-10}$

$F^- + H_2O \rightleftharpoons HF + OH^- \qquad K_b = 1.4 \times 10^{-11}$

f. $CH_3NH_3CN \longrightarrow CH_3NH_3^+ + CN^-$ ($K_b > K_a$ so it is a ***basic salt***)

$CH_3NH_3^+ \rightleftharpoons CH_3NH_2 + H^+ \qquad K_a = 2.28 \times 10^{-11}$

$CN^- + H_2O \rightleftharpoons HCN + OH^- \qquad Kb = 1.6 \times 10^{-5}$

129) 1. The pH is below 7, so we can eliminate any bases or basic salts (NaOH, NH_3 and NaCN)
2. The solution has high conductivity, so we can eliminate any weak acids (HCN and HF)
3. A 1.0M solution of a strong acid would have a pH of 0, so we can eliminate HCl.

   By process of elimination, the solution is ***NH_4Cl***, but we can check just because it's fun.

	$[NH_4^+]$ (M)	$[H^+]$ (M)	$[NH_3]$ (M)
I	1.0	0	0
C	- x	+ x	+ x
E	1.0 -x	x	x

$$K_a = \frac{[H^+][NH_3]}{[NH_4^+]} = 5.6 \times 10^{-10}$$

$$\frac{x^2}{1.0} = 5.6 \times 10^{-10}$$

$$x = 2.4 \times 10^{-5}\ M$$

pH = 4.6